EDF = Earliest deadline First (Scheduling on non-primitive uniprocessor)

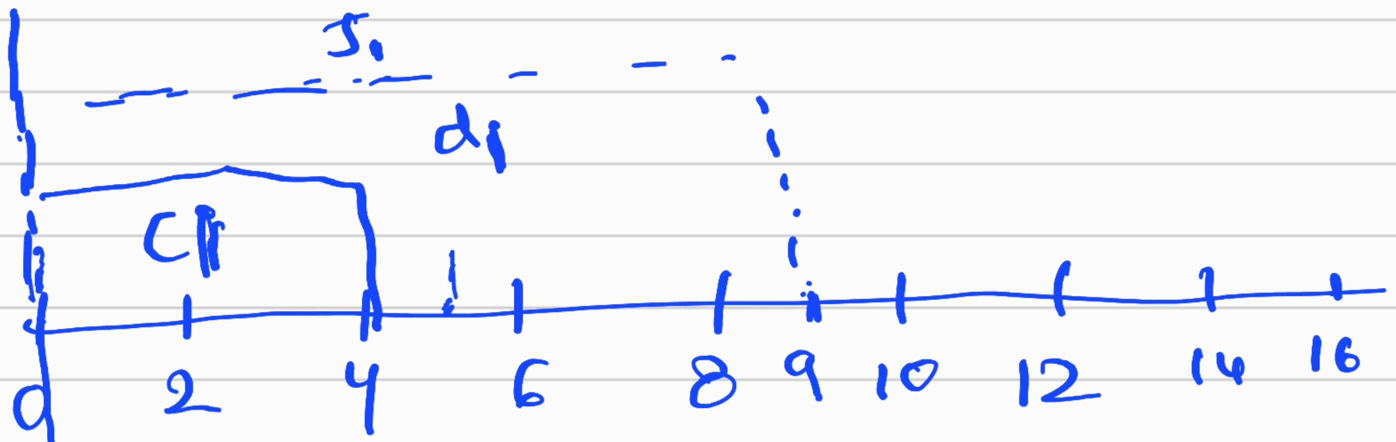
(uses 100% CPU)
→ static dynamic
= Priority according to task

Q. V

J_i → Tasks
C_i - Computation time
D_i - Relative deadline of task

(all tasks are synchro. & start at $t=0$)

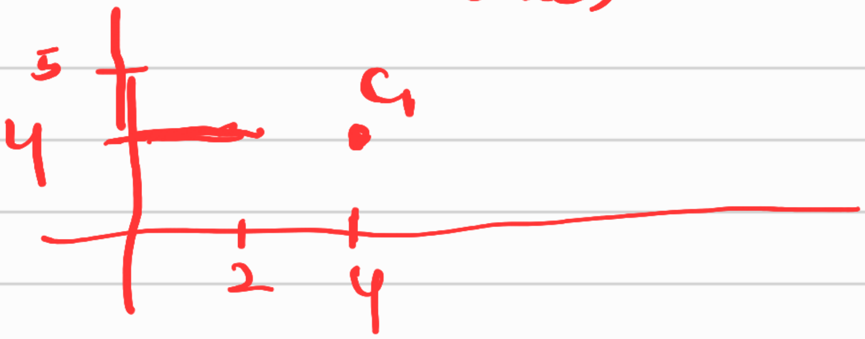
	J_1	J_2	J_3	J_4
C_i	4	5	2	3
D_i	9	16	5	10



$$\sum_{i=1} \frac{C_i}{T_i} = \frac{4}{9} + \frac{5}{16} + \frac{2}{5} + \frac{3}{10}$$

$D_i = T_i$

Calculate EDD - Firstly
(Earliest deadline
due)



$\approx 100\%$

$0.44 + 0.31 + 0.4 + 0.3$
$= 1.45$

145%
↳ CPU is not optimal

$\boxed{\text{Earliest D F}}$

	J_1	J_2	J_3	J_4
C_i	4	5	2	3
D_i	9	16	5	10

$D_i = T_i$ (Total time Period)

Step 1 : will take at $= 0$ the earliest deadline
So J_3 will start first
becz its deadline is 5 (Smallest)

Step 2 : will take J_1 (after J_3 Smallest is J_1 in deadline)

Step 3 :- $J_4 \rightarrow J_2$

Now

when draw first take

$\nearrow c_i$

J_3 - from 0 to 2 (2 intervals)

& D_3 = 5 (↑)

$\nearrow c_i$

J_1 → from 2 to 6 (4 intervals)

& D_1 = 9 ↑

$\nearrow c_i$

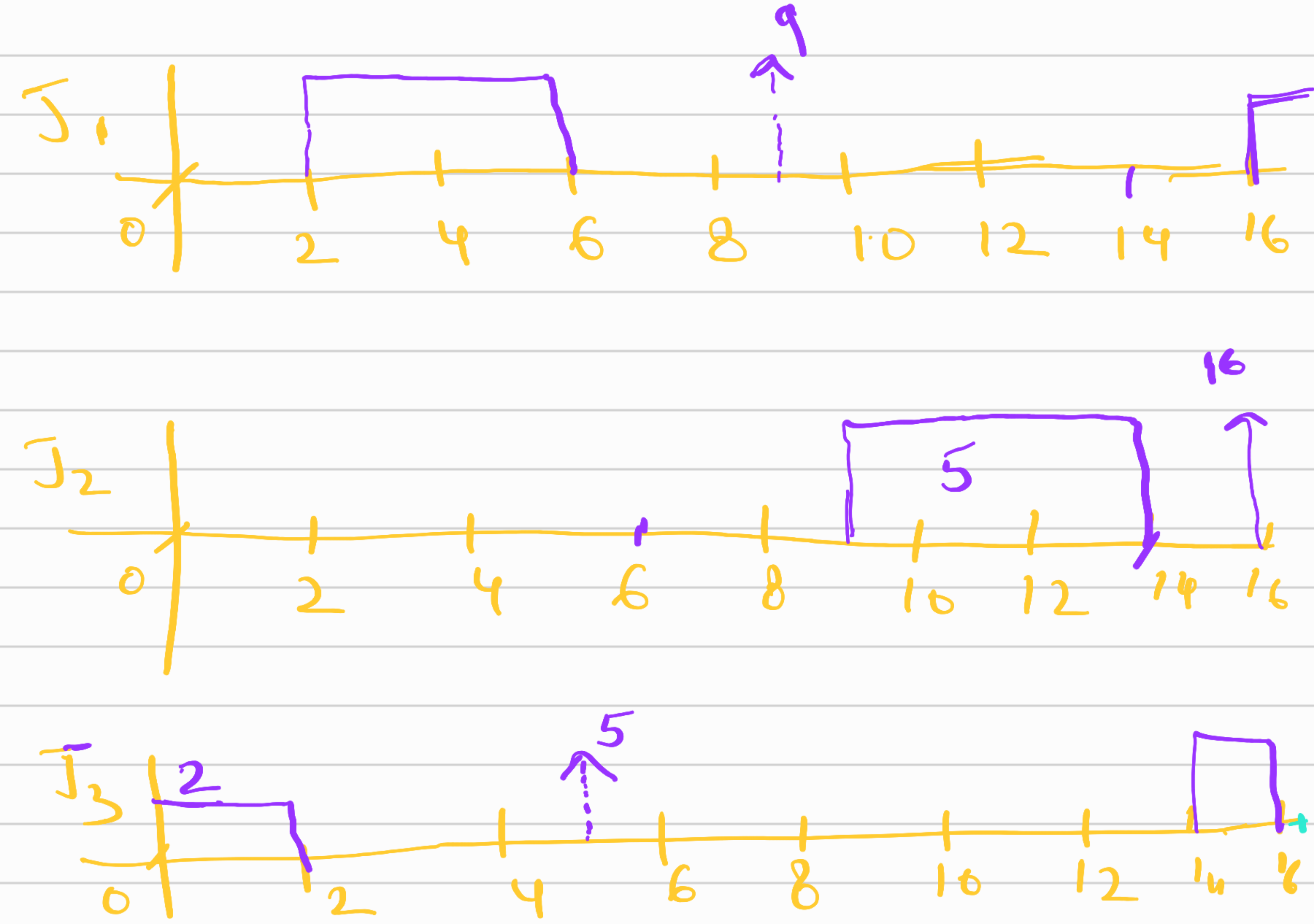
J_4 → from 6 to 9 (3 intervals)

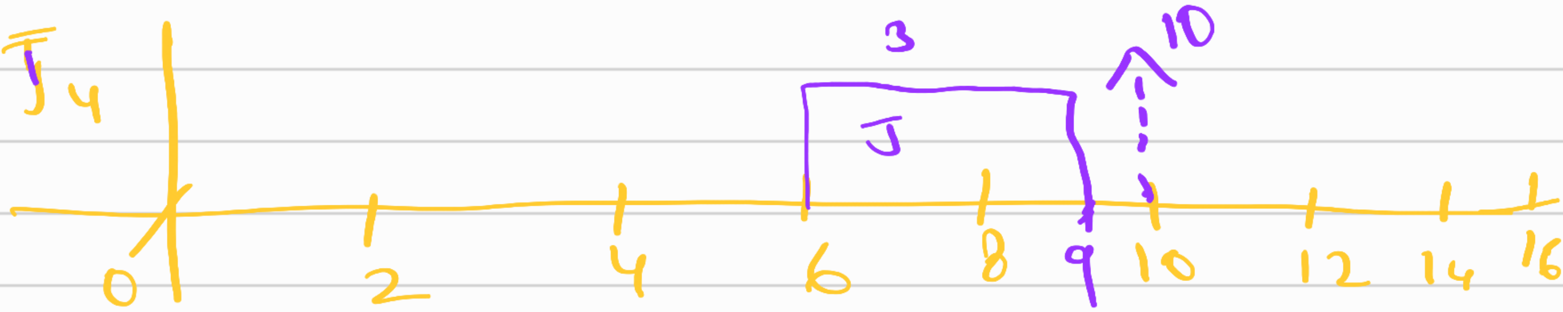
$\nearrow c_i$

J_2 - from 9 to 14 (5 intervals)

D_i = 16

Diagram :-





EDF – After all process then again it will start with the last task ended

for ex: J_4 ended at $14 = t$

then – J_3 start from $\underbrace{14 \text{ to } 16}$
2 (intervals)

& $D_3 = 19$

$J_1 \to$ start 16 to 20
(4 intervals)

D_1 23

J_4 – start at 20 to 23

D_4 24 (↑)

J_2 – start at 23 to 28

$D_2 = 30$

∴ The EDF is not feasible to below mention

D → G
C - F
C - E
D - F
B → C
$\boxed{A \to C}$
B → D

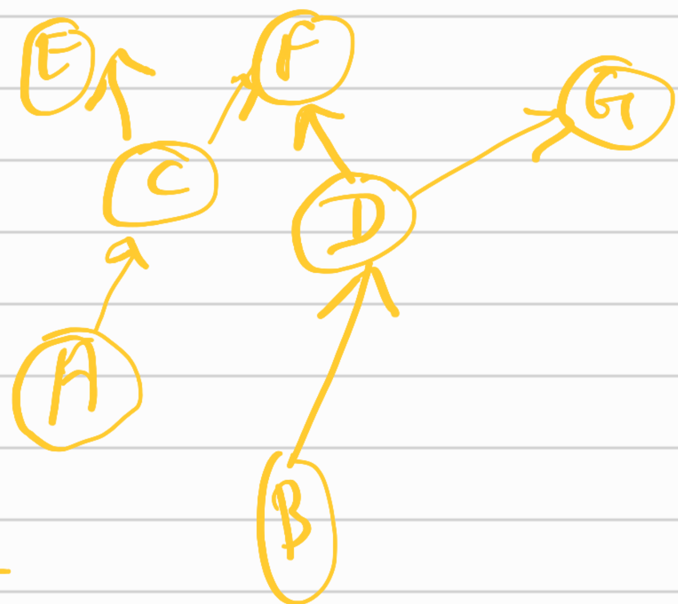
Task-2 A, B, C, D
E, F, G

Precedence relation :-

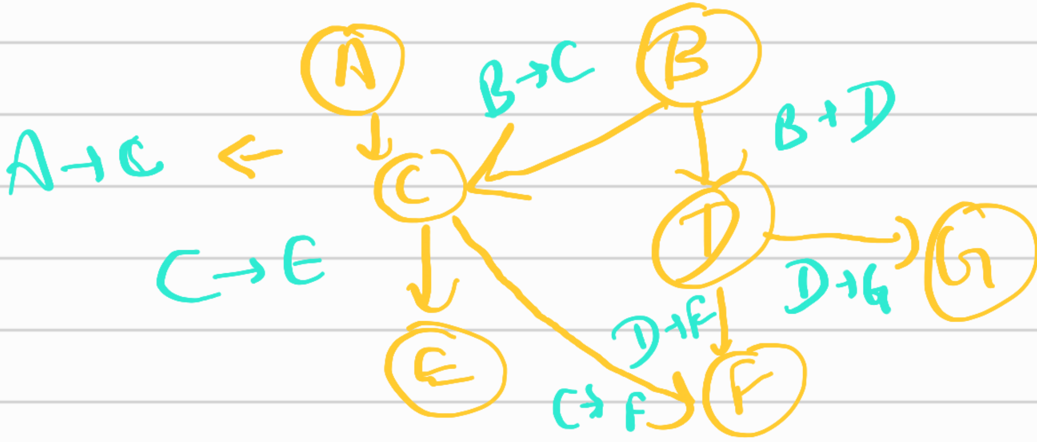
Precedence graph :-

- acyclic system
- Nodes → (flow of execution)
- Edges (Process)

Precedence relation :- A set of inequalities in the form of non-feasible time intervals.



→ doubt



Precedence graph.

Part -2 now all the task arrive at t=0

$D_i = 25$

$C_i = \{2, 3, 3, 5, 1, 2, 5\}$ – A B C D E F G

	C_i	d_i
A	2	25
B	3	25
C	3	25
D	5	25
E	1	25
F	2	25
G	5	25

* modification of release time :

Theorem :- Set of J (dependent task) → J (indep. task) modify by (timing Parameters)

If we apply above theorem :-

$$A \to C$$

(A immediate Predecessor of C)

then it will be followed Precedence Constraints.

$$S_C \geq r_C$$

(Start execution of C must not be Earlier than release time)

S_C → Start of execution of C

r_C → release time of C

$S_C \to \boxed{r_A + C_A}$ ($C_A = 2$ (computational time))

first it finish the execution of A

So release time can be replaced with max. b/w

$(r_c$ & $r_a + C_a)$

$$\boxed{r_C = \max(r_c, r_a + C_a)}$$

Formula : $r_i^* = \max(r_i, \max(r_h^* + C_h : J_h \to J_i))$

* modification of Deadlines

$A \to C$

$f_A \leq D_A$

(finish the task in the deadline)

$f_A \leq D_C - C_C$

(A must finish the Execution not later than max^m start time C)

So that the deadline D_A - can be in min $(D_C - C_C, D_A)$

$$\boxed{d_a^* = \min(D_A, D_C - C_C)}$$

$r_i = \underbrace{0, 0, 0, 0, 0, 0}, 0 \to$ assum

from $A \to G$

$r_i^* = \max(r_i, r_h + C_h)$

Step 1 $A \to C \to$ $r_A = \max(0, 0)$

$\downarrow$ nothing depended before $= 0$

$c_A = 2$

$c_C = 3$

$B \to C \to$ $r_B = \max\left[r_B, r_{prev} + c_{prev}\right]$

$C \to E$

$r_B = 0$

$r_C = \max\left[r_C, \max(r_A + c_A)\right]$

$\max\left[0, \max(0+2)\right]$

it is $A \to C$

$r_C = 2$

$B \to C$

$r_C = \max\left[r_C + \max(r_B + c_B)\right]$

$\max\left[0 + (0+3)\right]$

$\max(3)$

$r_C = 3$

with C is dependent on

both A, B but it's max
at 3 which is $B \to C$

Step 2 :-

$C \to E$

$$r_E = \max(r_E + \max(r_C + C_C))$$

$$\max(0 + \max(3+3))$$

$$\max(6)$$

$$r_E = 6$$ —*

Step-3

$B \to D$

$$r_D = \max(r_D + \max(r_B + C_B))$$

$$\max[(0 + \max(0+3)]$$

$$r_D = 3$$ —*

D_D -

$B \to D$

$$= D_D = \min(D_D, \min(D_B - C_B))$$

$$D_D = \min(25, (25-3))$$

Step-4

$D \xrightarrow{a} F = r_F = \max(r_F, (r_D + C_D))$

$= r_F = \max(0, (3+5))$

$\max(8)$

$r_F = 8$ — ★

$C \to F = r_F = \max(r_F + \max(r_C + C_C))$

$\max(0 + \max(3+3))$

$\max = 6 \to$ ★

So $F \to r_F = 8$ — ★

Step-5

$D \to G = r_G = \max(r_G, \max(r_D + C_D))$

$r_G = \max(0, \max(3+5))$

$r_G = 8$ — ★

* Now Solve Deadlines

Formula :-

$A \to B$ $\quad d^*_A = \min(d_a, d_b - c_b))$

$d^*_i = \min[d_i, \min(d^*_k - c_k))]$

$A \to C$

$d^*_A = \min(d_A, (d_C - c_C))$

$(25, (25-3))$

$\min(25, 22)$

$d^*_A = 22$

$d^*_A = \min[d_i, \min(d^*_k - c_k)]$

$d^*_A = \min(25, \min(22-2))$

$= 20$ — *

Step-2

$B \to C$ $\quad d^*_B = \min(25, (25-3))$

$\min(22)$

$= 22$

$d^*_B = \min(25, (22-3))$

$$d^*_B = \min(19)$$

C_D

$$B \to D = d^*_B = \min(25, (25-5))$$

$$\min(20)$$

$$= 20$$

C_D

$$d^*_B = \min(25, (20-5))$$

$$\min(25, 15)$$

$$d^*_B = 15 \quad — \bigstar$$

Step-3

$$\left.\begin{matrix} C \to E \\ C \to F \end{matrix}\right\}$$

$C \to E$ $\quad d^*_C \to \min(d_C, (d_E - C_E))$

$$\min(25, (25-1))$$

$$\min = 24$$

$$d^*_C = \min(d_C, (24-1))$$

$$23$$

$C \to F$ $= d^*_C - \min(25, (25-2))$

$\min(23)$ — ★

Step-4

$D \to G$

$$d^*_D = \min(d_D, (d_G - c_G))$$

$$(25, (25-5))$$

$\min = 20$ — ★

so overall Table :-

	c_i	r_i	r^*_i	d_i	d^*_i
A	2	0	0	25	20
B	3	0	0	25	15
C	3	0	3	25	23
D	5	0	3	25	20
E	1	0	6	25	25
F	2	0	8	25	25
G	5	0	8	25	25

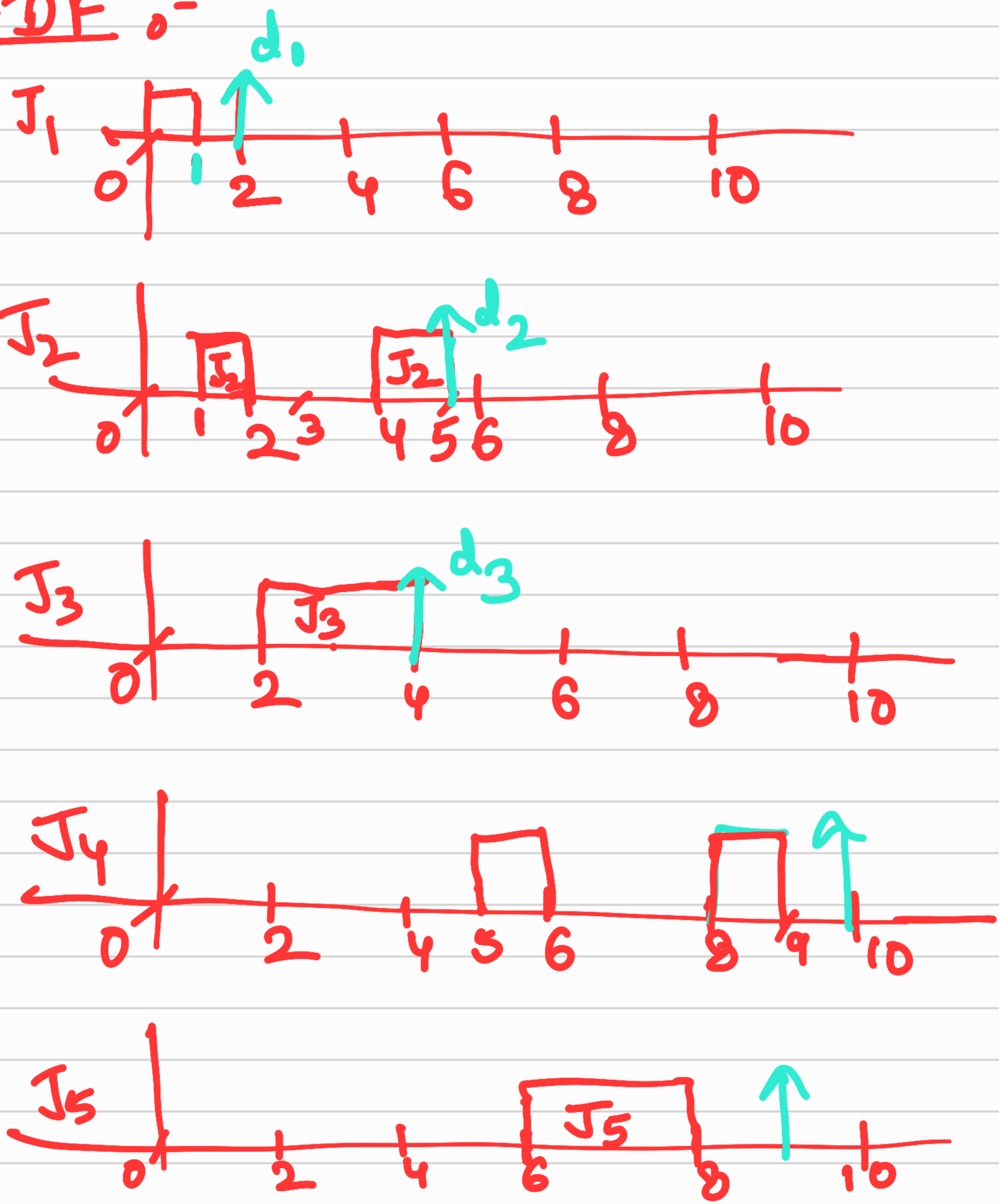
becz no dependen on other

Q.3 EDF = ?

$J_1 \to J_5$

	J_1	J_2	J_3	J_4	J_5
a_i:	0	0	2	3	6
c_i:	1	2	2	2	2
d_i:	2	5	4	10	9

EDF :-



Explanation :-

First J_1 will start

$d_1 = 2$, $c_1 = 1$

So (0 to 1) it' will complete

then J_2 will start at 1

$d_2 = 5$ (which is more $> J_3$)

So it will from 1 to 2

$c_2 = 2$ (becz J_3 start at 2)

high Priority to J_3 becz deadline is less.

from 2 to 4 $- J_3$ (will finish 2 intervals as $c_3 = 2$)

$d_3 = 4$

now J_2 finish another 1 interval

so it is 4 to 5

(before $d_2 = 5$ (it will end))

now J_4 will start at 5 but

$d_4 = 10$

$d_5 = 9$

$d_5 < d_4$

So more Priority to J_5 at $t=6$
before J_4 finish one interval
from 5 to 6

then $t=6$ J_5 will start $C_5=2$
So 6 to 8 it will finish
by 8

then again J_4 finish from 8
to 9

& $d_4=9$

" it is a feasible solution"

Q.6

Car Control Sys :-

Speed meas. = $C=5ms$, $T=20ms$
$D=20ms$

ABS Control = $C=10ms$, $T=40ms$
$D=40ms$

Fuel injection = $C=40ms$, $T=80ms$
$D=80ms$

other SW.

<u>with</u> C = worst Case Exe.
T = Sampling Period
D = Deadline

worst Case Exe. / Computing time
($C <= T$!)

C/T } ⇒ CPU (utilization of task)

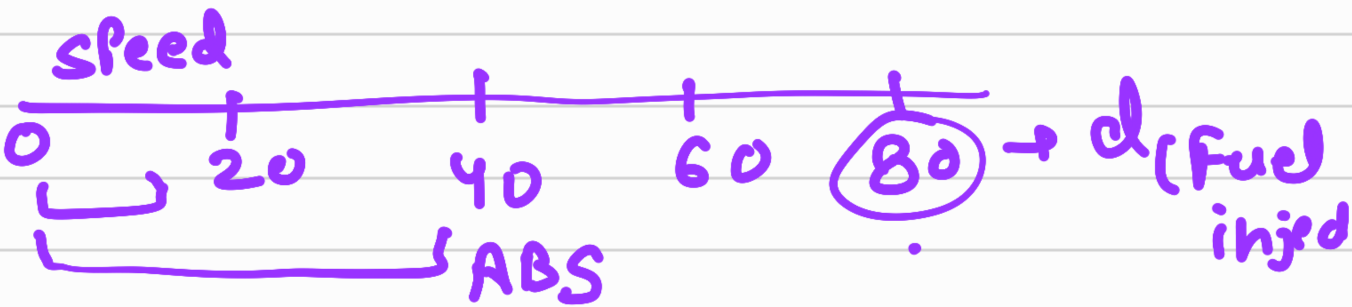
$U = \sum \frac{C_i}{T_i}$ = (utilization of task set)

if $U > 1$ (overload) —— *

$U <= 1$ (it will depend on the scheduling algo.)

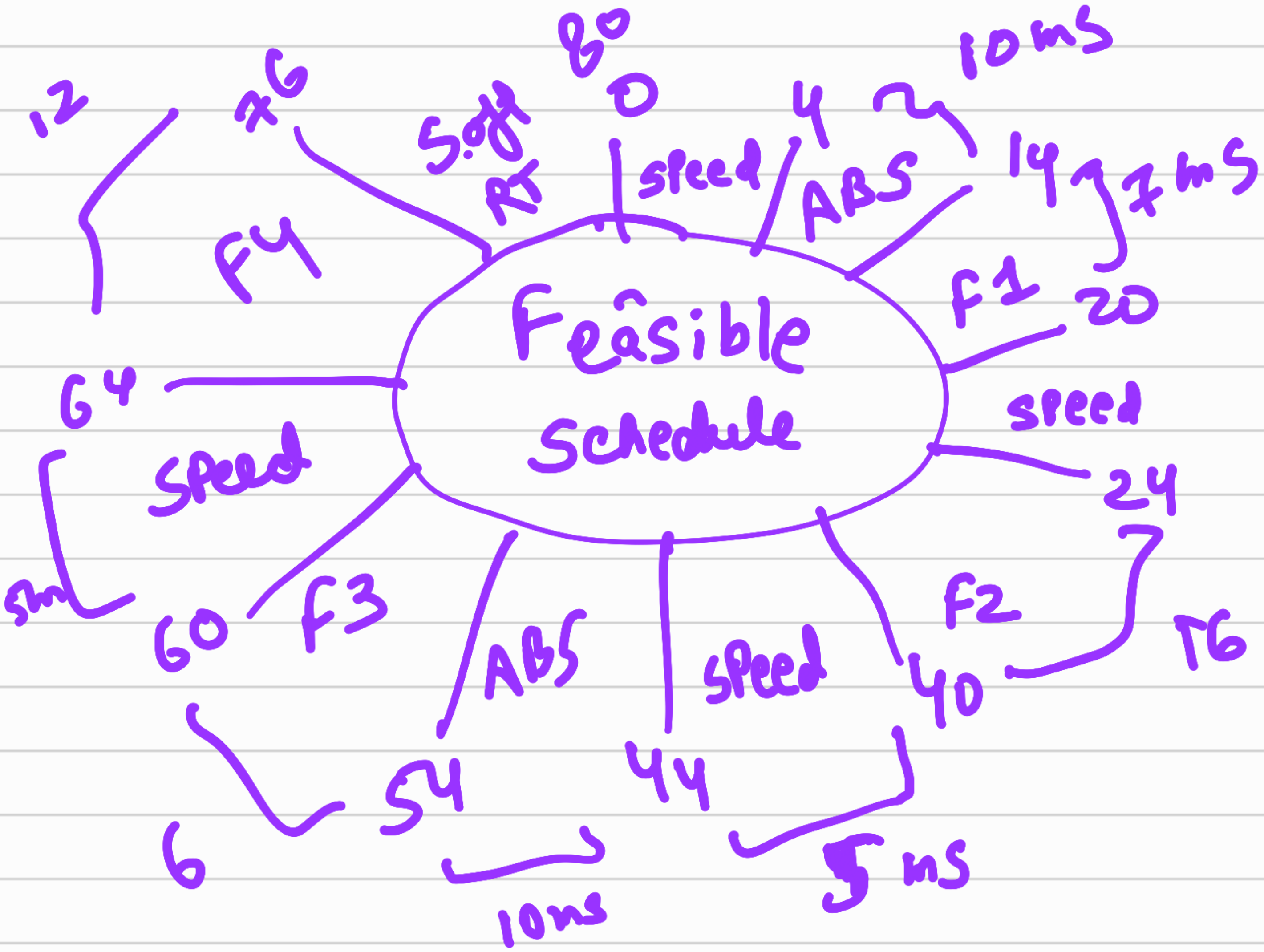
$U = 1$ (all deadlines met)

* Static Cyclic Scheduling



Shortest repeating Cycle = 80ms

* (Construction with EDF)



here ABS (one time Comes in 40ms time)

So first 0 to 4 Speed with (e_s = 5ms)

then

* EDF = $\sum U_i / T_i$ = $4/20 + 10/40 + 40/80$

$1/5 + 1/4 + 1/2$

$0.2 + 0.25 + 0.5$

$(U) < 1$

(Task is schedulable)

<u>RMS</u> – Tasks are independent

$D_i = T_i$